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Lean, Green & Smart

What's in store for tomorrow's factories? Process intelligence tools, outmaneuvering costly regulations and machine tools that learn their lessons well.

By John Teresko

Warning! Don't begin planning your factory of the future until you're ready to start revising yesterday's presumptions about optimization and efficiency, the environment, and machine intelligence.

Traditional manufacturing relationships – involving the building, the manufacturing process and the product – are playing more tightly against each other, often in new and unexpected ways.

Process Intelligence

Each wave of technology "rebuilds" the factory of the future. Today, the mounting tsunami of process intelligence tools is making its revisions. Although the implementations in progress are only nibbling at the potential, all signs indicate a watershed as great as Henry Ford's epochal work with mass production.

Of course, predicting the future is a dicey game as the initial exuberance for robots demonstrated. Once, while on a validation tour for *IndustryWeek*'s Best Plants awards in the early '90s, the plant manager of GM's Hamtramck, Mich., facility revealed a large storage room filled with industrial robots. "We had to remove them to achieve our productivity goals," he admitted." (The result helped make the plant a winner in that year's competition.)

How will process intelligence tools affect plants? Author Steve Brown positioned the contribution succinctly in his book title, "Strategic Manufacturing for Competitiveness Advantage, Transforming Operations From Shop Floor to Strategy," (Prentice Hall, London, 1996). Brown positions strategic manufacturing as the conceptual successor to lean manufacturing. He describes strategic manufacturing as "viewing production operations capabilities as a core competence, having a long term view of the business, being fully aware of all market opportunities, planning strategies to outperform competitors by targeting sectors in which it can compete while deliberately avoiding those in which it cannot, and engage in horizontal and vertical partnerships."

Brown's all-encompassing view of strategic manufacturing includes considerations of human resources, process technology, materials management, product innovations and last, but not least, corporate and manufacturing strategies. He says the "decisions will include investment in technology, expanding into new plants and adding capacity, strategic buyer/supplier relations, the extent of joint ventures with other firms, the extent of vertical integration and so on."

The Simulation Advantage: Simulation software is a key intelligence tool that is beginning to point industrial users toward the factory of the future. Those early adopters are gaining time and cost advantages provided by the 3-D simulation of production processes in the facilities that house them.

Not yet a universally used tool, this digital technology offers the potential of huge gains in bringing products to market more quickly, with higher quality and at lower overall costs. The early adopters tend to be in the automotive, aerospace, shipbuilding and defense industries.

Consider the strategic benefits claimed at a user group meeting of Delmia Corp., a Dassault Systemes company and supplier of simulation software:

- "Once considered a cost factor, [simulation] software is now viewed as a business opportunity that enhances competitiveness," says Thomas Wagner, Robert Bosch GmbH, citing a planning time reduction of 40 percent for Bosch due to the iterative process allowed by a digital factory.
- Noting a 5:1 annual return on an original investment of $200,000 in digital manufacturing, Northrop Grumman presenter Mike North reported, "with cycle times so short – only 28 months to complete the F-35 – we can't afford to not do simulation. It allows us to understand the process so we don't do things unnecessarily."
- "Being first to market is particularly important for smaller companies to be able to compete," noted Johann Gurtner of Siemens VDO, Commercial Vehicles. "Using digital factory planning, we are able to reduce the industrialization of new products from 24 [months] to eight months."
- Tanmoy Kumar, president, Hayes Lemmerz International, illustrated how the impact of modeling and simulation cuts across the manufacturing process from design through assembly. "Benefits include early detection and resolution of ergonomic, mechanical and material handling issues as well as optimized floor utilization. Across the board, modeling and simulation creates a collaborative environment."

In addition to the time and cost savings, simulation in the factory of the future could also serve as a sales tool, helping customers and upper management see exactly what they are getting. That also applies directly to the shop floor, allowing operators to use simulation as a training tool where they can virtually see the sequence of operations they need to perform. In addition, workers have access to up-to-date engineering data and work instructions on the screen with complete control to as much data as they need to effectively complete their operations.

"The increasing role that the 3-D virtual environment is playing throughout the entire product lifecycle is a dominant theme in today's manufacturing world," adds Bernard Charles, president and CEO of Dassault, Delmia's Paris-based parent company.

What To Expect: It's hard not to be intrigued by the benefits of simulation. A study of simulation tools by Ann Arbor, Mich.-based CIMdata Inc. elaborates: "On average, organizations using digital manufacturing technologies can reduce lead time to market by 30 percent, the number of design changes by 65 percent and the time spent in the manufacturing planning process by 40 percent. Production throughput can be increased by 15 percent, and overall production costs can be cut by 13 percent. (The early adopters say that an industrial process is not truly understood until an effort is made to simulate it.)

The study cautions that the greatest gains are typically achieved in large-scale complex, and/or difficult environments. To gain maximum advantage CIMdata recommends that the software be implemented as a component in an end-to-end, comprehensively integrated PLM (product lifecycle management) solution. "It should be based on a process orientation and include re-engineering of processes as part of the software implementation. If it is implemented as stand-alone point solutions, significantly lower payback can be expected."

From Virtual To Real: The National Research Council (NRC) has repeatedly emphasized the importance of modeling and simulation for the future of U.S. manufacturing. In one study NRC noted that "no other technology offers more than a fraction of the potential that modeling and simulation does for improving products, perfecting processes, reducing design-to-manufacturing cycle time and reducing product realization costs."

What are the chances for widespread pervasive use of simulation benefits in the factory of the future? In the U.S., federal technology development support is already under way.

The idea is to facilitate making simulation an easy part of the national manufacturing environment and not the near- monopoly of big-budget early adopters such as the Adam Opel AG plant in R sselsheim, Germany (a Delmia implementation). The Rosselsheim plant is a $3 billion tour de force that began producing Opel's Vectra model on Jan. 7, 2002. Annual capacity: 270,000 cars per year. The 3-D computer animations are said to almost exactly mirror reality, thus producing a level of reliability in the pre-production planning process that is superior to conventional methods. Manufacturing management is able to experiment with parameters such as facility layout, resource allocation, kaizen practices and alternate scheduling scenarios to prove out the best manufacturing processes.

One U.S. research initiative is under way at the National Institute of Standards and Technology (NIST), Gaithersburg, Md. "What our [research] program seeks is to help enable simulation to be as widespread and pervasive as the ubiquity of word-processing and spreadsheets," says NIST researcher Charles McLean, group leader, manufacturing simulation and modeling.

"We're looking at developing interface standards that would allow simulation systems to 'talk' to each other and 'talk' to other manufacturing software and exchange data." He envisions a much easier capability, in terms of time and cost, to simulate and model entire organizations including supply chains. He says standards will help in opening up the use and application of manufacturing simulation via lower cost of bringing in the data from other software systems. "Because of the lack of standards, everybody today is paying for custom integration solutions. Interface standards will enable industry, both the big guys and the small guys, to use the technology more effectively."

Green Opportunities

Remaking the way we make things" is both a mantra of architect Bill McDonough and the subtitle of a book, "Cradle To Cradle," he co-authored with his partner Michael Braungart. While the subtitle suggests that the book (North Point Press, a division of Farrar, Strauss and Giroux, New York, 2002) is only addressing issues of the manufacturing facility and its internal production processes, McDonough quickly emphasized to IW that he is also committed to the process that goes on outside the factory. McDonough believes that plant design is more than "shrink-wrapping" a structure around an optimized manufacturing process. His goal is to include the entire external commercial environment in the optimization process. He's talking about goals of integrating all the manufacturing flows from global to national down to the submicroscopic level.

"And then we design and situate a facility and a process within that continuum. We seek to remove the blinders from plant engineering questions," says McDonough. That was the philosophy he applied when chairman and CEO William Clay Ford Jr. asked him to revitalize Ford Motor Co.'s historic Rouge Center just a few miles south of Detroit. Innovations at the brownfield site include a new assembly plant with its 10-acre roof planted to sedum sod and water-permeable paving.

Is added operating cost a penalty of that philosophy? He insists that delivering operating efficiency is the guiding principle of both his architectural firm (McDonough + Partners, Charlottesville, Va.) and his consulting organization (McDonough Braungart Design Chemistry LLC). He says ecological concerns should be used to add to the bottom line.

For example, he says clients that can broadly leverage the entire industrial context for a factory (the product, process, and market) could find the benefits of freedom from regulation and increased revenue. "As they implement, they remove themselves from the requirements to be regulated." The ruling precept: Being controlled by a regulation is a signal of design failure. "If designs don't need to be regulated, business moves quicker and at lower cost."

One example: "in designing textile plants, we've developed facilities where the water going out is cleaner than the water going in." Does that add cost? McDonough claims savings because any necessary chemicals added to the water are more closely monitored resulting in less usage. Other savings come from the elimination of paperwork procedures normally required by regulations. And if any hazardous chemicals are removed, employee exposure and resulting insurance/legal costs are reduced or eliminated.

The firm begins each factory project with deep benchmarking to uncover all of the implications. "For example, in the textile industry we've looked closely at approximately 8,000 chemicals to see if substitute processes can be found when carcinogenic or mutagenic problems are present." In doing so, he claims to have been able to reduce the production costs of textile mills by an average of 20 percent. McDonough says that such a holistic approach to plant design can obviate the need to relocate a manufacturing facility. He notes, for example, the continued competitiveness of a Swiss textile mill (Rohner Textil AG) he designed in 1993. "It's still staving off its far-east competitors."

The partners see the factory of the future involving manufacturing in a new relationship with environmentalism. "When talking about the future of our environment, choosing between what is bad and less bad isn't good enough. We need to – and can – revolutionize the way we make things so that the manufactured world – the world designed by people – is as safe and effective as the one nature gave us."

McDonough says that the new relationship doesn't violate the business necessity for a profitable existence. "The greatest challenge is a lack of vision in industrial leadership as well as entrenched engineering protocols of people who don't want to be creative or think. The economics are indisputable because they are built into the system. It is just the people who don't want to change."

He also says the concept is attractive to both U.S. political parties. "If you're Republican you'll like what we're doing because we're talking about commerce that is free from regulation. The Democrats like it because we've got jobs that can be maintained and businesses that don't pollute the world. There are no losers."

Sentient Machine Tools

The make-to-order trend is the long-term challenge and opportunity for all those that have a stake in the factory of the future, says Paul Warndorf, vice president, technology, The Association for Manufacturing Technology (AMT), McLean, Va. No aspect of manufacturing will be unaffected by the commercial pursuit of that objective – neither the manufacturing processes and equipment nor the physical plants housing them.

To Warndorf, flexibility, as in the Dell model, has become the major goal. Another example of the systemic influence of flexibility is the C-Flex programmable body shop tooling system that is replacing body style specific tooling and related equipment at GM.

GM's concept allows multiple body panels (floor pans, deck lids, hoods, engine compartments, etc.) to be welded with the same set of programmable tools and robots, explains Jerry Elson, vice president vehicle operations. Model specific tooling is not required, and plants can be smaller.

With the flexibility of the C-Flex system, GM is reducing square footage requirements in assembly plant body shops by as much as 150,000 square feet, while saving millions of dollars to renovate body shops for new products.

Another, more fundamental impact of make-to-order is how that drive for flexibility will redefine the basis of our manufacturing civilization, the machine tool. Warndorf says that trend began with the advent of multi-tasking machines such as Mazak Corp.'s Integrex. The ongoing mission, as Warndorf sees it, is to lead a national effort to develop the next generation of machine tools – the smart machine. He says America must develop, validate, and demonstrate the enabling technologies necessary to allow manufacturing equipment to make decisions based upon acquired knowledge. This will allow for the production of the first and every subsequent part and part feature to specification without unscheduled delays, adds John Kohls, director-Machining Xcellence, TechSolve Inc., Cincinnati.

TechSolve, a manufacturing consultancy, is part of an AMT organized U.S. coalition dedicated to spurring the technical infrastructure of U.S. manufacturing. Its first initiative is directed toward research and gaining federal support for a smart machine initiative. Other members include the National Center for Defense Manufacturing and Machining, National Center for Manufacturing Sciences, National Coalition for Advanced Manufacturing, National Tooling and Machining Association, and Society for Manufacturing Engineers.

Although you won't see smart machines exhibited at AMT's fall manufacturing show, a sense of urgency is growing. At NIST, smart machine tool development is seen as a national security imperative, says researcher Hans Soons, program manager, Manufacturing Engineering Laboratory. In addition to being an industry forum, NIST's smart machine contributions center on technical infrastructure – metrology, process methods standards and testbeds.

If NIST's wish list is realized, Soons predicts the smart machines in the factory of the future will:

- Know its capability/ condition and can be interviewed.
- Know how to machine a part in an optimal manner.
- Monitor, diagnose and optimize itself.
- Know the quality of its work.
- Learn.